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**THE FACTORS WHICH DETERMINE
THE QUALITY OF TEA.**

BY

HAROLD H. MANN, D. Sc.,

SCIENTIFIC OFFICER TO THE INDIAN TEA ASSOCIATION.

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PREFATORY NOTE.

The present report is a development of the material of an address delivered, from a somewhat different point of view however in each case, to large and representative gathering of planters in Kalighat (Sylhet), in Silchar, and in Jalpaiguri, during March and May of the present year (1907). At the time I was asked to put the address in a more permanent form, and consented to do so if I were allowed to enlarge it and make it more complete. The present is the result. It will be noted that, in the present paper, I speak more dogmatically than is usually the case. This is owing to the fact that it is a development of a lecture, and the data on which my statements are based will be generally found in one or other of my various publications on tea culture and manufacture.

H. H. M.



THE FACTORS WHICH DETERMINE THE QUALITY OF TEA.

The determination of the nature and relative importance of the factors which are responsible for the high or low quality of almost any agricultural product forms one of the most subtle and difficult problems which have yet been posed. It is perfectly well known that the areas capable of producing the highest grade tobacco have hitherto been strictly limited. The same is the case with wheat, with potatoes, with hops, with cotton, with coffee, with wine and dozens of other crops which could be named. And in each case the peculiar character of particular soils, particular climatic conditions, or particular methods of preparation have been indicated as the cause of the special quality there obtained, without in any single case the character of the product being definitely and convincingly traced to its source. A mystery, in fact, attaches to the production of quality in all these cases which has never yet been completely cleared up.

In no case is this more marked than with tea. The variation of the product from different places, at different times of the year, and in different seasons, exceeds that with almost any of the crops I have named. Hitherto no satisfactory explanation of this variation has been forthcoming, and I do not think that any complete one can yet be given. But the time has come when it would appear profitable to review the progress that has been made in the determination of the question, and to give at any rate some indication of the factors which are known to be liable to lower the quality, and the avoidance of which naturally will improve the product.

THE CONSTITUENTS OF TEA.

Before going into a consideration of these factors, it may be well to describe shortly the constituents to which tea owes the value it may possess. These are principally three in number: (1) the essential oil producing the flavour, (2) the caffeine or theine producing the stimulating action, and (3) the tannin giving the astringency, and when fermented, the colour to the liquor. It is extremely probable that there are other materials having very important functions, particularly in producing the flavour of the tea, but for the time being it will be quite enough to consider these three constituents.

The *Essential Oil*, though often spoken of, is in reality a material of which extremely little is known, and it has never been prepared in any quantity. Some years ago, Mr. Bamber, in Ceylon, distilled a very large quantity of tea (80 lbs. I believe) with the idea of preparing an amount of essential oil for investigation, but the quantity obtained was so small as to render a thorough examination impossible. It can only be said, in fact, that it is an oily body which can be driven off from the tea at high temperature, more especially along with the steam when the leaf is wet, and which on exposure to the atmosphere quickly changes into a resin with a very marked tea like smell. It is evidently one of the chief factors in determining flavour.

It is equally certain that the *Caffeine* is the principal stimulating material in the tea, and for long its quantity was supposed, therefore, to bear a close relationship to the market value. This supposition is now proved, without a doubt, to be quite unfounded, and though the *medical* value of tea may vary with the quantity of caffeine, the market value certainly does not. It is, however, present in quantities which vary from 3 to 5 per cent. in good teas, and in the lowest grades it may be down to 2 or 3 per cent.

The third constituent of tea of primary importance is the *Tannin*. This has generally, if not always, been considered by the medical profession as the objectionable part of tea, a conclusion come to, perhaps, on insufficient evidence. The value of tea in the market on the other hand, seems to be closely connected with the quantity of tannin easily extracted from the tea by boiling water. The teas, in fact, containing the most tannin usually have the greater value, unless possessed of less flavour. This fact was pointed out long ago by Hooper, and has been confirmed on many occasions since his investigations were published.

If teas possessing marked flavour be eliminated, and the total soluble matter and the tannin be determined and considered together, it is, in fact, possible to form a fair idea of the market value of a tea so far as it depends on the liquor given on infusion.

The tannin is, as a matter of fact, the chief if not the only source of pungency in teas, more particularly when in an unfermented condition, and when changed by fermentation it is the principal factor determining the colour of the liquor. Thus the market points

which have value in a tea liquor may be said to be chiefly caused as follows:—

- (a) Flavour.—Caused principally by the essential oil.
- (b) Pungency.—Caused in greatest measure by the unfermented tannin.
- (c) Colour of Liquor.—Caused chiefly by the fermented tannin.
- (d) Body of Liquor.—Measured principally by the total soluble matter, of which a larger part is tannin fermented and unfermented.

If we leave aside the question of flavour for the moment, it will be therefore evident that the constituents which it is important to investigate from a commercial point of view are (1) the sum total of substances capable of being dissolved under tea drinking conditions, and (2) the tannin in all its various forms.

The tannin of tea was first prepared pure in Java six years ago. It is a white crystalline solid when quite dry, but it attracts water so strongly that a minute's exposure to ordinary atmospheric conditions is sufficient to turn the crystals into a pool of syrup. It is exceedingly astringent, but not bitter.

If it be recognised that these constituents are those which in principal measure determine the quality of tea, the rational method of ascertaining the cause of quality would be to find out how changing conditions would lead to changes in the quantity of these several constituents. Unfortunately, till recently and in a measure even yet, this method has, however, been inapplicable owing to (1) the absence of a method for measuring the constituents of tea other than caffeine, (2) the impossibility of obtaining exactly regulated conditions in growing the tea in practice. We have therefore in the present discussion of the subject to draw on general information obtained in the course of tea planting, on inferences drawn from analyses of the soil and in a measure, of the leaf, and on comparison of the results in different districts and different seasons.

FACTORS AFFECTING QUALITY.

In the past the principal factors leading to the production of quality have stated to be—

- (1) elevation and, in a measure, latitude;
- (2) regularity and sufficiency of rainfall;

- (3) variety or jat plant ;
- (4) special character of soil and manuring ;
- (5) kind of pruning ;
- (6) method of plucking ;
- (7) system of manufacture.

It may at once be said that each of these factors has its influence, and we will now consider in detail what the influence is in each particular case.

EFFECT OF ELEVATION.

It was long supposed that the primary factor determining flavour at any rate was that of elevation, and in a less measure that of latitude. High level teas were always known as flavoury teas, and if one limits the reference to one district, one kind of soil, and one variety of plant, there remains little doubt that elevation has a great deal to do with the production of flavour.

Darjeeling was, from the beginning, known as the district, *par excellence*, for flavour in Northern India. The Kangra Valley, though it did not produce high grade tea in other respects, yet often got a most marked flavour. When Ceylon began to grow tea, it was the high level districts which at once took the lead in turning out flavoury teas, and the same might be said, in a less measure, of the Nilgiris. Inside these districts, it is true, it was by no means always the highest level gardens which gave the best tea, and occasionally a garden lying very high, for some reason or other, always produced decidedly inferior teas.

The general consensus of opinion was such, however, as to lead in the early nineties (1890-1895) to the extensive opening out of tea gardens on the plateaux of South India, the whole of which lie at a level of 4,200 feet or over. The anticipation was that with a soil in which the tea plant is extremely luxuriant, with a jat or variety of plant which yields more easily and more copiously than the "China" or low hybrid common in Darjeeling, and with an elevation about corresponding to the best districts for flavour in India or Ceylon, a high flavour and a large yield were at the same time assured. So far this result has not been attained, and the tea, though giving a large yield, has not been of the quality which was expected. I will discuss later on why this is the case, but in the meantime it may be stated that the cause probably lies in the special character of the soil. This is generally speaking, very light, and for

such a light soil very, or rather excessively, rich in organic nitrogenous matters. I shall show that excess of nitrogenous constituents in the soil always seems to lead to the production of luxuriance at the expense of flavour in the tea. But, if this is the case, time will afford a cure, and the Travancore plateau, if it does not produce the class of tea we associate with Darjeeling or the high gardens in Ceylon, yet is likely to give a flavoury tea at any rate at certain seasons of the year. I think such a result may fairly be anticipated.

The reason of the flavour character of teas grown at high elevation is difficult to fathom. My own theory, though it is only pure theory, is that the essential oil is one of the principal lines of defence of the plant against any enemies which may attack it. Let there be any slightly unfavourable conditions, such as the attack of green fly, cold weather insufficient to stop growth altogether, or the like, and the reserves, if I may so speak of the plant, are called up in defence. These reserves, in part, consist in a larger secretion of essential oil, and hence a flavoury tea is produced. I will touch again on this matter when speaking of green fly.

REGULAR AND SUFFICIENT RAINFALL.

The importance of a regular and sufficient rainfall to the healthiness and luxuriance of the tea plant cannot be exaggerated. The ideal districts for tea are those in which there is a total fall of one hundred inches of rain or thereabouts, which occurs without any very long drought throughout the season. The average total rainfall for a period varying from thirty to sixty years at various centres in the Indian tea districts has been as follows* :—

Assam Valley—		Inches.
Dibrugarh	...	112.11
Sibsagar	...	94.35
Nazira ...	...	89.06
Tezpur ...	...	73.08
Nowgong	...	77.10
Gauhati	...	67.19
Surma Valley—		
Silchar...	...	121.43
Sylhet ...	...	156.64

* These and the following figures relating to rainfall have been obtained from the Indian Meteorological Memoirs, Vol. XVII. (1904.)

Duars—

Jalpaiguri	...	... 125.72
Buxa...	...	... 208.61

Darjeeling—

Darjeeling	...	... 121.80
Kurseong	...	... 160.65
Chittagong ...	...	... 105.09
Dehra Dun ...	...	... 79.63
Palampur (Kangra Valley)	...	... 110.91

The rainfall is, however, distributed in a very different fashion in these various places. While Dibrugarh rarely has a month without really substantial rain, and while there is a very good rainfall in the really important months of March and April, the same reliance cannot be placed on receiving enough moisture at that time in some of the other districts. To avoid needless complication of figures I will only illustrate this with a few typical stations in the districts, and for these give the average rainfall for each month for many years.

	Dibrugarh.	Tezpur.	Silchar.	Buxa.*	Darjeeling.	Chittagong.	Palampur.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
January ...	1.49	0.59	0.64	1.10	0.76	0.41	5.13
February ...	2.53	0.90	2.32	1.02	1.08	1.16	5.26
March ...	5.54	2.43	7.93	2.80	2.01	2.14	4.05
April ...	9.84	6.08	18.56	8.70	4.08	4.47	2.11
May ...	14.18	9.68	15.72	20.24	7.83	9.68	2.41
June ...	18.26	12.69	20.39	39.27	24.19	22.81	9.30
July ...	20.01	14.33	19.98	50.42	31.74	22.92	34.24
August ...	18.66	12.84	18.69	42.79	25.98	19.99	33.24
September ...	13.61	8.96	13.95	30.76	18.34	13.03	11.63
October ...	6.05	3.36	6.40	10.19	5.35	6.41	1.13
November ...	1.11	0.72	1.31	0.67	0.24	1.49	0.42
December ...	0.83	0.50	0.54	0.65	0.20	0.58	1.99

It is evident from these figures that a part from extreme conditions they do not altogether favour the idea that the regularity of the rainfall is anything like a paramount condition in the production of

*I take Buxa as being more typical Duars than Jalpaiguri. Neither of them (and I have no others) represent really the conditions.

good tea, though it probably has an influence. Judged by the above figures Dibrugarh and Cachar (Silchar) should give the best tea. The former does so; the latter, though in former times the best, is now poor. While one suspects that the principal cause of the decline in the quality of tea in Cachar lies elsewhere (*vide infra*), yet the most that can be said from these figures is that while a regular rainfall is an advantage in growing high quality leaf, it is not by any means the principal determining cause in any case.

EFFECT OF JAT OF PLANT.

If we put aside as of minor importance, apart from extreme cases, the effect of the regularity of the rainfall, the next factor which has been considered by practical men as of leading influence is that of variety of *jat* of plant. It is curious to note that as far back as 1835, Dr. Griffith, who was sent to Assam to investigate the probability of tea culture there being a success, in his report strongly argued in favour of importing "China" seed for use on the proposed gardens, for the very reason we are now discussing,—namely the probability that this would give much better tea, and that wild stocks are likely to be "more or less irreclaimable." Other botanists were of the same opinion* and it must be confessed that experience with other plants justified the position which they took up, and also justified the importing of China seed. In the present case the result proved disastrous. In the plains it is now universally recognised that while the China plant may give a slightly more flavoured tea, yet this is obtained at such a cost of pungency and liquor, that it would never pay now-a-days to plant China plant. In the high level districts the matter is by no means so clear. Here, in fact, where flavour is the principal cause of the high price obtained for the tea, there is a very general, though by no means universal, opinion that the replacement of China by hybrid or by "Assam-indigenous" tea cannot be done even at high elevations, without loss of quality.

I have had one series of careful experiments brought to my notice in this connection, conducted by Mr. E. C. Partridge on the Balasun Tea Estate. Part of that garden is composed of "China" plant, and part at about the same elevation, of a hybrid, approaching indigenous, in type. He writes me recently as to the result of his tests, as follows:—"I find there is a great difference in the flavour and the market value

**Cf.* A. De Candolle (1836) "Wild tea will most probably give a flavour much stronger, more bitter, with inferior flavour."

during the second flush, the China teas sometimes fetching as much as a shilling a pound more than that from the Assam bushes, but later on in the season from August, there appears to be little or no difference, and they realise about the same prices till the close of the season. Of course other gardens at higher elevations may differ from me." Similar opinions have been expressed to me from other leading planters in the same districts, and though usually they are based on general impression, yet it seems likely that they represent the actual facts as to the superior flavour of the tea obtained, at any rate during the second flush, from the China *jat* of tea.

Even, however, were this universally the case, it would not compensate, in the plains, for the poorer yield given by the China type of plant, nor for the increased difficulty in plucking the leaf. The only question there, lies between the *Assam-indigenous* and the *Manipuri jats*, for the "*Lushai*" and "*Naga*" types may be left out of consideration in practical tea planting. The *Manipuri* type has been extensively planted even in the high quality districts like Dibrugarh and the Sadiya Road, because it is more healthy, less liable to blights (particularly to "Red Rust"), because it is less susceptible to drought and generally because it is a hardier plant and one more easy to manage.

The result has been somewhat confusing, and must more or less remain so until we are able by analysis of the leaf prepared from plants of the same age, at the same place, on the same soil, to determine in what the difference consists. At present, however, we have gardens, which I could name, on the Sadiya Road, producing as high grade tea as their neighbours, and yet planted almost entirely with "*Manipuri*" plant, while others in which the "*Assam-indigenous*" plant has been chiefly employed, in the same district, do not reach the standard of neighbouring gardens. There may, and probably are, contributory causes, and I think there is little doubt, on the whole, that other things being equal, the "*Assam-indigenous*" will produce better tea than the "*Manipuri*" *jat*. At the same time, the former type should only be planted under favourable circumstances as it needs if it is to be a success, (1) friable, light land; (2) well drained land; (3) reliable rains in the spring; (4) very careful pruning and plucking. If it be planted, as I have seen in Cachar, on low, somewhat heavy land, where *Manipuri* flourished quite well, it rapidly becomes unhealthy and hidebound, and ceases to yield. If put in a district liable to drought as I have noticed in South Sylhet, the result will be almost equally disappointing.

Efforts have been made from time to time, though never in a systematic manner, to breed a type of plant which would combine the hardness of the dark leaved *Manipuri* with the delicacy of flavour obtained from the *Assam-indigenous* type. So far none of these efforts have succeeded in evolving a new type of the character demanded. It is a line of experiment which is well worth further investigation, and has promise of giving ultimately a type of greater value than any yet known;—but such experiment will have to be conducted under careful supervision to achieve any real results. The fertilisation of individual flowers from other individual flowers by hand would have to be made, and this in successive generations until the new type became fixed, and no result could be looked for at least under twenty years. It is a class of work in which the slightest carelessness will spoil the whole result, and the chances of "dropping across" a good type of plant by accident are infinitesimal.

EFFECT OF SOIL ON QUALITY.

I pass on now to a consideration of the effect of the soil on quality. This will, probably, when study has gone further than has been the case at present, prove to be the most important influence in determining the question though at present any attempt to exactly find out where and how the influence is exerted, is met by a mass of apparent contradictions. Some points, however, seem to stand out with fair clearness both with regard to the effect of the physical and of the chemical characters of the soil on quality.

In the first place, it seems to be pretty certain that high quality will not be long produced from land in the absence of a fairly large root range for the tea. This can be well illustrated from Cachar. Judging by the quality of the tea formerly produced on *teela* and plateau gardens there is nothing radically wrong with the climate as far as the production of high quality tea is concerned. When flat or *bheel* lands began to be opened out under tea, there was a rapid deterioration in quality of Cachar teas, relatively at any rate, to the remainder of the Indian tea districts. This was attributed, at the time, and probably correctly as we shall see, to the enormous excess of organic matter present in these *bheel* soils. But in many cases the excess of organic matter has now disappeared and still the quality remains low. There may be and are subsidiary reasons why this should be the case, but I fancy we are justified in attributing part at any rate of the low quality to the restricted root range of the plants.

The fact might be illustrated from other districts such as Nowgong, Assam, and from the extremely beneficial effect of drainage on quality in certain cases.

The cause of this curious effect of limited root range lies probably in the determining effect possessed by the mineral constituents of soil on quality, combined with the fact that they are not capable of being carried up and down the soil by ordinary movement of water to anything like the extent that nitrogenous matters are carried, and must hence be sought out in the soil by the plant rootlets. If the latter find hindrances in the way of their wide extension it is only natural, more particularly in a poor soil, that their mineral nutrition is limited, and hence the quality of tea is low.

I have repeatedly in various publications indicated how the root range can be extended, by deep narrow drains, by the use of *sau* (*Albizia stipulata*) or other similar trees, or by trenching between the rows. With regard to the first of these methods I may say that I am becoming every year more convinced of the general utility of well designed drains in almost every class of soil, and would now by no means limit them to three feet deep in most cases, if they can be made deeper and still retain the narrow character which they ought to have. To secure this several of the more advanced planters in Assam have introduced the use of a special narrow draining hoe, not more than 4 to 5 inches wide, which in many soils enables a more satisfactory drain to be made than the *kodali* generally in use on the gardens.

The use of the *sau* tree needs little more than a passing remark. While increasing evidence seems to point to its utility being in a large measure due to the way in which it softens the soil within the range of its roots, and so makes them more permeable to the delicate tea roots, yet I have been disappointed in the result of its use in actually deepening the soil. It does bring this about, but much more slowly than I, at one time, thought,—but its usefulness in this direction cannot be neglected.

The method of increasing the root range by trenching in between the rows of tea, and either filling or not filling the trenches so made with bheel soil, jungle, or cattle manure is only the introduction of the past few years on a very large scale, but has proved of great value, and is likely to prove of still greater value in the future. Not only will it probably be a valuable means of increasing the root range, but also will be the method of the future for applying bulky manures

like bheel soil to the tea, and also for barying green manuring plants like the *boga-medeloa* (*Tephrosia candida*), *arhar-dal* (*Cajanus indicus*), which grow high with straight stems and can be buried in the cold weather.

The method of applying the system is usually to dig trenches—quite narrow trenches—between alternate rows of tea to a depth of from eighteen inches to two feet. My own ideas would be that two feet is better than eighteen inches, but others have not found this to be the case, and it probably depends much on the class of land concerned. Into these trenches, which should not be kept open larger than possible, the bheel soil, cattle manure mixed with soil, jungle, *boga-medeloa* plants and the like are placed and covered up with the soil. In this way rootlets of the plants as can be easily seen a few months later are quickly drawn down to the bottom of the trench, and are thus able to make use of the material which is buried. The rootlets of the *sau* tree penetrate below the trench even quicker than those of the tea, but wherever the former penetrate they open the soil to such an extent that the tea roots will follow them. In a number of cases which I have seen, it is the custom to reduce the extra cost, by leaving the regular deep hoe undone on the plots which are trenched, and trusting to ordinary light cultivation of the remainder of the land to do all that is needed. I mention this method here simply as a means in many cases of increasing the root development of the plants, feeling that until the increase in root range is secured, attempts to obtain high grade teas cannot usually be more than partially successful.

But while a considerable root range is necessary, it is also requisite that there be sufficient plant food in the soil, and that it should be well balanced in character. In this connection there are two opinions strongly held in certain quarters which hardly seem to bear close examination. The first of these is that slow growth necessarily means quality. This opinion has no doubt many facts which apparently lend its support. In the first place, in the earlier part of the year, when the flushes are not so heavy or so rapid as later in the season, in Assam at any rate, the best tea of the year is produced: then there is a period, during the rains, when the tea is inferior, and finally at the end of the season, when growth has again become slower, a much higher grade and more flavoured tea is produced.

Though these are the facts which have generally been noticed in Assam, yet it by no means follows that this change of quality

through the season is a necessity. It may well be due to less careful plucking in the height of the season when it is important above all things to get the leaf off the bushes, or it may be due to the fact that less care can naturally be taken in manufacturing one hundred maunds of tea per day in the same factory which both earlier and later in the season manufactured ten maunds per day. I can say this because certain gardens have long succeeded in maintaining their quality on an extremely even grade throughout the year, and to the number others have recently been added. I am confirmed in the opinion too because the way in which the quality varies according to season varies in the different districts. While in Assam June teas are usually the best, I am informed that in Sylhet this is by no means the case. All districts seem to finish up the season with the most flavoury teas in the year.

There is another argument against slow growth, as such, being a principal factor in producing good tea, for where this is the case, it would follow that gardens making the smallest crop should also make the highest quality if the plucking were the same.* This is not entirely the case even in Darjeeling, and certainly it is very much the reverse in the plains districts. In general, in fact, districts and gardens giving abnormally small yields (unless it be known that the small yield is due to exceptionally fine plucking) generally also make low or only medium quality tea. This may be due to inferior soil, or to lack of cultivation, or some other case but in this case there is slow growth, and yet low quality. On the other hand there are gardens on which growth is exceptionally vigorous and exceptionally fast, which also produce excellent tea. Some of the younger gardens on the Sadiya Road illustrate this point well, for they make nine, ten, or eleven maunds per arce of tea valued over ten pence per pound.

The most that can be said as to the connection of slow growth and quality is that there may be some connection, provided that in both cases the growth is perfectly healthy, and that the check comes from conditions outside the plant itself. That even in this form the proposition is necessarily true I am not sure, but it is the only form in which it can be accepted for a moment. Additional evidence that

*This would not necessarily be the case where the differences were slight, as the increased crop in the one case might be due to a larger number of shoots being present and not to increased rapidity of the growth of any individual shoot. But the above argument certainly holds for the extreme cases noted above.



there is something in it has come to hand from Heeleaka Experimental Station this year, by the partial analysis of the leaf from all the manurial plots for every month. The soluble matter and the tannin in the leaf (on which the value of the tea depends) went down on the whole as the crop went up, and then again increased as toward the end of the season the crop went down. The following are the actual figures:—

				Crop per acre.	Percentage Soluble Matter.
				Pounds.	
June	...	...	...	276.0	49.25
July	...	...	...	344.2	48.62
August	...	...	...	362.8	43.61
September	...	...	...	374.9	40.78
October	...	...	...	390.6	37.79
November	...	...	...	89.4	

The explanation of the connection between very vigorous growth and lowering of quality, if such there be, is probably connected with the destruction of the regular balance of the necessary constituents in the supply of food absorbed by the plants. In the above case, where the valuable contents of the leaf decrease at the height of the rains, what occurs is possibly as follows, though I only put forward the idea as at present an unproved theory. The plant has to absorb its food from the soil in water solution. Under normal circumstances the water in the soil contains nitrogenous matter, phosphoric acid, potash, &c., in a definite proportion to one another. But seeing that the first of these is much more soluble in water than the others, if there is an exceptional amount of water passing through the soil, an excessive proportion of nitrogenous matters will be contained in the soil water. This is what happens in the rains, and so results in a rapid but somewhat abnormal growth, and relative decline in quality.

As a matter of fact it would appear that at the height of the rains there are present all the conditions of a soil too highly manured with nitrogenous manures like bheel soil, or of a peat bheel itself, in a less intense measure. Now excessive bheel soil dressing is universally considered as liable to cause loss of quality and the tea on soils very rich in organic and nitrogenous matters is nearly always weak and poor. All these facts lend support to the belief that it is not the

presence in large amount of any particular constituent, but the relative quantity or balance of all which is vital to the manufacture of good tea.

Now in the course of the history of a tea estate, the first of all the constituents to become reduced below the optimum or most favourable amount is this very nitrogenous matter of which I have just been speaking. This is almost always the case in our districts. The consequence of this loss is not necessarily a lowering of quality,—though always a lowering of yield,—as if there is sufficient of other constituents the growth is merely reduced without changing in character. But as a secondary result of the reduction in growth the bush becomes unhealthy in consequence, and then, almost inevitably the quality as well as the yield falls off.

This leads us to conclusions with respect to the general relationship of manuring to quality. If the manuring is such as to create an excess of nitrogenous matter available for the plant's use beyond the amount of phosphoric acid, potash, &c., available in the soil to produce a well-balanced plant food, then the quality is liable to decline: if the manuring does not supply such an excess, it may even improve quality by improving the health of the bushes, and is extremely likely to do so if at the same time these other constituents are present in the manure itself or in abundance in the soil.

This apart, from any question of increase of yield, is the justification of manuring from a point of view of quality, and at the same time indicates how best it should be carried out. If nitrogenous matter is the chief active constituent of the manure,—and it should be so in nearly every case,—the quantity applied at one time should be very limited, and should not in any very considerable degree upset the balance of plant food in the soil. Hence frequent applications of small quantities of manure are to be recommended rather than larger dressing at longer intervals.

When we consider that in our experiments at Heeleaka the repeated small dressings also gave a better result in point of yield, and that this was the case with cattle manure, rape or mustard cake, and castor cake, the best method of manuring seems perfectly clear, whether one considers crop or quality. I am, in fact, inclined to imagine that the evil reputation attached to manuring from a quality point of view is almost entirely due to the application of too much manure at one time. From what we can see at present it seems

(except perhaps in some very exceptional cases) that better results are obtained by putting 6½ tons of cattle manure per acre on to land in each of three successive years than by putting 20 tons on at the same time; that the same advantage is noticed in using 5 maunds of any class of oilcake per acre in each of three successive years as against putting on 15 maunds all at once. It is most likely the same would be the case with artificial manures like Nitrate of Soda, Saltpetre, and Sulphate of Ammonia though definite data are not in my hands as yet.

It is the fact that it rather tends to retain a proper balance among the materials available for plant food in the soil, than to cause a large excess of nitrogenous matter to be present that makes green manuring with *mati-kalai* (*Phaseolus mungo*) or *dhaincha* (*Sesbania cannabina*), a process that can be conducted without danger to quality in ordinary cases. *Sau* trees have been blamed for lowering the quality of the tea on certain gardens, but this has been for the totally different reason that the shade made the growth long and stalky. Properly used in the way I have described elsewhere*, there has now been proved to be no danger on this score, precisely as would have been anticipated from my argument here.

Hitherto direct manuring for quality has not been a marked success, as no particular instance can be cited where the addition of phosphoric acid, potash, or other of the mineral constituents required by the tea has resulted directly in a marked change of quality. On the other hand the managers of some of the gardens in which manuring with highly phosphatic manures like bones has been carried out for a number of years (like Hoolungoorie, Jorhat, Assam) or where basic slag was buried along with tea prunings according to the Ceylon system some years ago, are of opinion that the quality of the tea has been improved thereby, though there is no direct citable evidence of the fact. Though there is, likewise, not sufficient evidence that the direct addition of superphosphate of lime or other phosphates does directly influence the quality, yet it is almost proved that it forms a paying addition to a purely nitrogenous manure like Nitrate of Soda, even when yield alone is considered†. Its influence will *tend*, in any case, to improve the quality of the tea, though the effect may not be capable of being valued by a broker. Beyond this one cannot at

*See Green Manuring in Tea Culture in India, Calcutta, 1906.

†The Heeleaka Experimental Station Report investigations in 1905 and 1906, Calcutta, 1907.

the present stage of investigation recommend any direct manuring to improve the quality of tea.

EFFECT OF GREEN-FLY.

One of the most curious points in considering the question of quality in tea is the effect of green-fly.* The appearance of this pest in May or June is immediately followed by a considerable improvement in the tea produced, though, of course, the yield is much diminished. No explanation has yet been given, for this curious action, and it is the only insect attacking tea which has a similar effect. The actual injury done by the insect so far as I have been able to make out is confined to the young green stalk. Even there no outward injury is noticeable, but if the outer skin (epidermis) of the young green shoot be carefully scraped off, the stalk below will be found to be covered with large numbers of slightly discoloured, spots, almost microscopic in size, and which would not be noticed without careful examination with a lens.

This rise in quality may perhaps be explained by the suggestion mentioned (page 6) when dealing with the effect of elevation, that the increase in flavour may be due to the reaction of the plant against the slight injury caused by the insect, this injury being insufficient to destroy any vital tissues. If this were the case, the flavour (that is the essential oil) would be in the nature of a defence against further attack, and this is likely, for essential oils are usually objected to by almost all low forms of life. If this explanation holds, then the effect of green-fly on the quality would be more marked on a thoroughly vigorous garden than on an estate where the bushes were more or less unhealthy from whatever cause, and in practice this is generally found to be the case. I am aware that this explanation is only a theoretical one, but at present it fits all the facts, and may guide perhaps in deciding on the best method by which to treat the pest.

There are, in fact, two systems of dealing with a block attacked badly with green-fly. One of these is to pluck off all the obviously attacked leaf and shoots at once; the other to allow it to remain, and not pluck at all, when, ordinarily after about three weeks or so, the attack gradually passes off. The former method has the advantage of removing, along with many insects, a large number of the eggs† and so reducing the pest; it causes a rapid growth of new shoots, and

* The green-fly of tea so called is really a Jassid bug (*Clorita flavescens*).

† It is not quite certain when the eggs of the green-fly are laid, but it is most probably in the unopened leaf bud.

if these are not again badly attacked the bush appears to get over the blight; but as will be at once seen it involves plucking the bush hard at a time of the season (May and June) when it is important that the growth should be carefully preserved. On the other hand, if the growth be left till the green-fly lifts in the ordinary course, the planter is trusting to the reacting power of the plant to protect it against further injury as above described, by making the shoots less palatable to the insect. Though the immediate leaf is lost under this system, a very vigorous growth takes place when the blight "lifts," as vigorous, in fact, as when the blighted leaf is plucked off, and at the same time the growth on the bushes, so important at that time of the year, is left on the bushes. From this it will be seen that, on present evidence, I am in favour of keeping one's hand off the bushes in the case of a bad attack of green-fly, at least until the time when it is certain that the bushes will not throw it off on their own account. If they are really vigorous bushes this will hardly ever fail; the reaction against the green-fly attack will be comparatively rapid and complete. If on the other hand the bushes have little vitality, it may be necessary to pluck close in order to get rid of the blight. This last will probably, however, be found ultimately to further decrease the vitality of the bushes, whose lack of vigour was the cause of their not throwing off the blight as they otherwise would have done.

EFFECT OF PRUNING ON QUALITY.

It is generally, in the next place, recognised that manner of pruning has something to do with the quality of the tea produced on a certain estate. That poor quality follows heavy pruning is universally recognised. Some say, however, that heavy pruning leads to loss of quality for several years, others that it only affects it during the year that the heavy pruning is done. I have never been able to collect data to decide this point to my own satisfaction, but everyone is agreed that during the year which follows the heavy pruning the liquor is weak, non-pungent, and without flavour. Whether this condition is due to the length of the immature shoot on which the leaf is grown (see page 20 under plucking) or to some other cause there is no evidence to show at present.

This being the case, however, it would naturally be supposed that the nearer the growth induced by the method of pruning was to that induced by heavy pruning the poorer would be the tea. In other words, by thoroughly cleaning out the bushes of all weak shoots the

growth be forced into a few vigorous channels it would be supposed that, temporarily at any rate, the quality would suffer. And, in a measure, this has been found to be the case. It is a common place to hear it stated that the lighter the pruning the more flavoury, though not always the stronger, the tea. And this has been in many cases the reason for the continuance of a system of merely cutting the bushes flat, or nearly flat, across the top, instead of the more rational modern methods.

It has been proved, however, in Upper Assam that unless the cleaning out of the bushes be carried unreasonably far, that any loss in quality is very temporary, and can be almost entirely eliminated by careful plucking both at the beginning and later in the season. Moreover, it has been shown that, again with the same reserves against extreme "stick-pruning," the flavour is affected more than the strength, and in fact, the latter may be positively increased by "cleaner" pruning if the amount of "scrub" in the bushes had previously been high. Again it has also been brought to light that in old gardens, at any rate, the loss in quality due to loss of vitality when old-fashioned high-pruning, without cleaning out was done, quickly exceeded any loss of quality due to the cleaner pruning. From our present point of view, therefore, while very light pruning, cutting across the top of the bushes without cleaning out at all and the like methods may give higher quality when a garden is in very vigorous condition (like young bushes or virgin land), in a position where the vitality of the bushes has to be kept up with great care, it is inadmissible. The slight and temporary loss in quality due to the throwing of the growth into few very vigorous shoots, must be avoided, as far as is possible, by more careful plucking at the early part of the season, and not by a reversion to methods of pruning which, while temporarily improving the quality ultimately lead to lowered vitality, and hence a lowered grade of tea on this account.

The time of pruning may also have an indirect effect on quality. It seems to be generally recognised in the Assam Valley at any rate that June teas are the best of the year, and that hence anything which can increase the proportion of June teas in the crop will *ipso facto* improve the average quality. Hence, the argument would be that it would be wise to prune early in order to get more growth in June. This system has been carried out with great success in Dibrugarh, but applied elsewhere the danger of checked growth from

heavy drought in February, March or April seems to have been too great and late pruning has been adopted as giving the safest if not the highest quality results. I think under existing conditions this adoption of late pruning is right. But if by careful autumn and cold weather cultivation or other means it were possible to make the bushes more independent of drought, the question of earlier pruning would have to be again considered, if the highest quality is to be obtained. I draw the attention of planters to the possibility of improving their quality without undergoing the present risk of damaging the bushes, if only they can be made more independent of spring droughts, as they are naturally in Dibrugarh.

EFFECT OF PLUCKING ON QUALITY.

It has often been considered, especially by those without long planting experience, that an infallible method of preparing good tea was to pluck finer. To such people the problem of fine tea making resolved itself largely, if not entirely, into a difference between three leaves and a bud, two leaves and a bud, one leaf and a bud, &c., &c. There is nothing more certain now, however, that this is not the case. A garden which makes poor tea will not make it good by such a simple expedient. It may obtain a higher average price, but such higher price will be often found to be due to little more than the exclusion of the coarser grades, and not to much improved price for the individual grades themselves. On the same bush at the same time the youngest leaf is always the most rich in soluble matter, if other conditions remain the same, but this is the most that can be said for quality as a result of *fine plucking* alone.

The problem is, however, to grow the maximum quantity of the finest possible leaf, containing the largest amount of those constituents which are desired, and, in connection with this, there are certain principles which I think may now be held down with some confidence.

(1) The closer a shoot is plucked to its point of origin, the better will be the tea produced. Though this is now generally recognised, yet a careful test was made during September 1905 of leaf from the same lot of bushes. Half were plucked normally after ten days, and half was allowed to run for twenty days, but were then plucked equally fine with the first half. The total soluble matter in the two cases was—

- (a) ten-day growth=43.10 %.
- (b) twenty-day growth=40.25 %.

In this case it should be noticed that the difference was not due to different fineness of plucking, but was solely due to the fact that second lot was growing at the end of a long stalk, while the first was plucked down to the "*janum*."

(2) The difference between "close" and "long" plucking (of equal fineness) becomes greater as the season goes on. I do not know that there are any exact experiments to back this statement, but I make it as the result of a good deal of observation.

From these principles it will be seen to follow that if quality alone be considered, the bushes should be plucked as *close* as possible throughout the season, and that this closeness becomes more important as the season advances. But this statement which is made from the point of view of quality alone, has to be very greatly modified when one considered the health and vigour of the bushes. Close plucking in the early part of the season is, of course, fatal, and I am confident that anxiety to make good tea in May and June by closer plucking than would otherwise be carried out is at the bottom of the rapid decline of many a good garden. If one keeps in view the reasons for allowing considerable growth at the beginning of the year, this will however be avoided. These reasons are (1) to provide wood for pruning in the following year; (2) to give the bush enough leaf growth to keep it well supplied with breathing organs during the remainder of the season; (3) to afford plenty of leaf axils from which the secondary shoots or "flushes" may arise. The closeness with which tea may safely be plucked in the early part of the season depends so much on the special conditions of climate, of soil, of *jat*, and of condition of bushes on the particular garden that it is impossible to lay down any generally applicable rule, but I would insist strongly on the necessity of considering the future health of the bushes more than the quality during the early months of the season, until enough growth has been made to satisfy the purposes already indicated.

Having obtained the necessary growth on the bushes, the best way to deal with the plucking from a point of view of getting the best quality of tea is still a very moot point. Generally speaking, it is the custom in most of the tea districts to carefully distinguish between "ready" and immature leaf,—that is to say, between leaf which has reached the orthodox "two leaves and a bud" above the *janum* or other leaf which is, for the time being, to be left on the bushes, and leaf which has "one leaf and a bud" or even only an unopened bud

above the same point, and pluck over the garden as quickly as possible—say in not more than seven days. This method has proved a great success in practice, and many of our high quality gardens adopt it. But it will be seen that the leaf obtained is bound to be somewhat irregular. For supposing a shoot is only slightly too little developed to pluck at one round, it must be considerably too much developed at the next round; if on the other hand it were just forming in the first case, it might be just ready at the second. Hence if plucking in seven days is carried out leaf will be plucked from shoots in every state from six days over-developed to shoots in the pink of condition. I do not see how under the ordinary system of plucking this difficulty can be overcome. No doubt the ideal would be to pluck every plot on the garden every day taking ready leaf only, or in other words to have a gang of pluckers attached to every block in the garden who were always plucking there, but I recognise that such a system seems to be, under existing conditions of labour and supervision, impracticable, though whether it will always be so is open to doubt. But apart from such a method which as I have said is at present purely an ideal, I do not see how the leaf can be made as even as would be desirable, given the usual system of plucking.

In Upper Assam, and in a few gardens elsewhere, the difficulty of securing young even leaf has in a measure been got over by adopting a system (after sufficient growth is considered to have been obtained on the bushes in the early part of the season) of plucking *all* the young leaf on the bushes at each round of the garden (so-called plucking "black,") and thus having no such thing as ready leaf. Under this system any leaf which can be obtained, whether "two leaves and a bud" or "one leaf and a bud" or even in some cases the bud only above the "*janum*" is taken at each round, but to compensate for the severity of the plucking the rounds do not usually occur oftener than once in ten days, and sometimes not oftener than once in eleven or twelve days. The result is that all the leaf obtained is young, none of it older than ten, eleven, or twelve days, as the case may be, and hence though the leaf still varies in age yet it is all young. By this means, at any rate under the Upper Assam and especially the Sadiya Road conditions, a large crop of very fine leaf is obtained.

Whether a system like this is applicable everywhere is doubtful. Upper Assam has, as I have said, ideal conditions of climate and soil and what is possible there may well be impossible, without leading

to deterioration of the plant, in other and less favoured districts. However, I have seen a slightly modified form of the system carried out with success in a young garden in the Duars, and it is being tested in the Jorhat district of Assam at Heeleaka. The results are not yet by any means complete, and there seems, at present, a possibility that some deterioration of the tea may result from its adoption at Heeleaka, but certainly finer leaf has so far to have been obtained, and the yield has somewhat increased. Until these experiments reach a satisfactory conclusion, the most one can suggest is that experiments on the lines of the Sadiya Road system as described above might be tried on selected blocks in gardens in different parts of our districts, and the results noted. The matter is, at present, one for further experiment.

There is only one further point in relation to this matter to which I need refer—namely, the question of plucking *banjhi* shoots in the early part of the season, so far as quality is concerned. In the latter part of the year I do not think there is any question, the *banjhi* shoots must be plucked if they occur, for the sake of obtaining further growth, whether they are made into tea or no, and their number can be very much limited and reduced by careful clean pruning. But early in the season the matter is different, and views in the matter vary very considerably. On the one hand, if a bush shows a tendency to go *banjhi* after three leaves have grown on the first flush, some planters insist that it must be plucked in order to induce secondary growth; others that if the garden is well cultivated, new growth will start after an interval from the *banjhi* shoot, and that this so-called “burst *banjhi*” growth will give exceedingly flavoured tea without materially, if at all, reducing the total yield of the bush. So far as the quality of “burst *banjhi*” flush is concerned, every probability would be that it is highly flavoured, though no very careful test has been so far made. And on other grounds, as I have indicated in previous publications,* it seems advisable not to pluck these shoots if it can be avoided. But this matter, too, awaits the careful detailed inquiry necessary before a system of work for quality can be laid down with any amount of certainty.

EFFECT OF MANUFACTURE.

The leaf having been grown and plucked, can be spoilt in the manufacture. It has always been a matter of controversy as

* The Pests and Blights of the Tea Plant, Watt and Mann, 1903. Chap. VII., page 103.



to what influence the manufacture really has in the quality of tea produced. “Good tea is made on the garden and not in the factory” has too often been the first maxim learnt by a young planter, and comparative neglect of improvement, close supervision, and care in the factory has been the result. In recent years, and more particularly in the last two or three, it is being more and more recognised that while good tea can be made by no known process from inferior leaf, yet in a vast number of cases the tea actually produced is inferior to what could, by closer supervision and better regulated manufacture, be made from the same leaf.

WITHERING.

It is now well known and I think well recognised that the first process in black tea manufacture—the withering—is of the extreme importance for the making of good tea, and that it cannot be hastened or the time it takes shortened without loss of quality. At a normal withering temperature of 70° to 85° F. it may in general* be stated that according to my experiments the time required varies from eighteen to twenty-four hours, after which there is a fairly rapid decline in the amount of enzyme (or unorganised ferment) in the leaf with corresponding loss of quality in the final product. In actual practice the principle that the time must be regulated is now admitted, but it has been found that apparently the best time is a little greater than that indicated in my experiments. It is also greater, as I found, when the atmosphere is very moist. The important point to recognise is that a definite time is required, that the chemical process going on in the leaf during the withering are independent of the amount of wilting, and that the proper amount of wilting must be secured if in any way possible at the same time as the leaf is chemically for manufacture.

It will be evident, however, that the leaf brought into the factory after say five hours plucking is not all by any means in the same condition. Some has already been plucked for over four hours and the chemical processes I have spoken of are already well started, while some is just off the bushes. This being the case, it follows of necessity that the tea made cannot be so good as if the leaf could all be secured in similar condition. This has been recognised by a number of planters in Upper Assam, and they have organised

* For details and carefully worked out tables, see “Ferment of the Tea Leaf,” Part III., Calcutta, 1904, H. H. Mann.

a system on their gardens whereby the leaf is brought into the factory almost immediately after plucking and continually throughout the day. The pluckers are only provided with a small basket holding one or at most two seers of leaf, and immediately this is filled it is weighed on the spot itself, the woman, credited with the amount, and the leaf carried into the factory by special men as soon as a man's load has accumulated. Working on this system the very best results have been obtained. I have never seen the leaf reach the factory in such good condition as under this method, and the prices gained by some of the gardens working thus have fully justified it. I am informed that the actual cost of plucking on a garden situated well with respect to the factory has not been materially increased, because the pluckers, not having to bring in their own leaf made a longer day's work in the tea itself. The leaf when it reached the factory is, of course, spread at once.

I have recently been informed of another case where the knowledge as to the actual process going on during withering has led to more convenient working, without loss of quality. In past times, the use of artificial withering by fans has been condemned in the high quality districts, but this has probably been because when used it has usually been in order to reduce the time of withering, which cannot be done, as we have seen, without loss of quality. If fans could be used to finish off a wither which was not obtainable otherwise in the proper time owing to unfavourable weather conditions it would appear that their function would be a valuable one. This has been realised in the case I am noting, and now under such unfavourable weather conditions a loft with fans is used to finish off the withering of four or five lots of leaf during the day, and this is done while making high quality tea.

ROLLING.

Regarding the next process in manufacture I shall have little to say. The amount and method of rolling is so dependent on the character of the product desired by the market at the particular moment, that it is difficult to make statements generally applicable. But, as rolling can be regarded as the first stage of the fermentation it may be urged—

(1) that the rollers be kept absolutely clean and as nearly as possible aseptic (*i.e.*, free from microbes) by scalding or steaming every day ;

(2) that the temperature in the rolling room should be regulated as carefully as that in the fermenting room ;

(3) that the temperature in the roller itself should be kept down as low as possible, though especially if the rolling be hard is not often easy to keep it below 84° F. as it would be best to do ;

(4) that, in the case of hard rolling, it is advisable to substitute two or three shorter rolls with aeration and sifting between for one long roll, because the temperature can by that means be prevented from rising so high ;

(5) that, in cases where the rolling is hard enough to actually express juice, it does *not* seem advisable to put this juice back into the leaf. This is the result of a number of experiments, but I must confess I do not as yet understand the reason for the injurious effect on the quality which the return of this juice appears to have.

But, after all, rolling is essentially the first stage of fermentation, its principal function being to bring the juice of the leaf, with the ferment or ferments contained in it, into contact with the air. On the amount to which this is done, or in other words to the hardness of the rolling (provided the leaf be equally withered) depends the amount of fermentation which takes place, and hence the depth of colour of the liquor given by the resulting tea. The actual *modus operandi* of the fermentation process will be somewhat different according as to whether the primary importance is attached to the thickness and character of the liquor or to the flavour of the tea.

FERMENTATION.

In either case, however, there are certain conditions to fulfil if the best results are to be attained.

(1) The fermenting room must be clean and as aseptic as possible whatever the arrangements for fermentation. If it is not so, "flavour" will be more affected than "liquor," though both will be injured. The freedom from microbes is best secured by daily steaming of the beds used for fermentation, or if that is not feasible, by scalding with boiling water coupled with thorough removal of any refuse and juice.

(2) The surface on which the fermenting leaf is placed should be impermeable to tea juice, so that the latter can be completely

removed by washing. The fact that this can be done is one of the principal advantages of glass, or tiles, or enamelled iron (provided the last does not chip) over cement. If the surface is made from pure cement the penetration is very slight and not so very objectionable.

(3) The fermenting leaf should not come in contact with iron, or darkening of the liquors will occur. The possibility of chipping taking place and so the fermenting leaf being brought into contact with iron is the chief objection to enamelled iron as a material for fermenting beds. Galvanised iron is considerably worse for the same reason. Sheet zinc is not objectionable, except for the fact that zinc is slightly soluble in tea juice, and hence a trace of the metal gets into the final tea. Copper is not objectionable so long as it is absolutely clean, but a trace of juice left in contact with it induces verdigris and makes it poisonous.

(4) Unless special arrangements are made for the even circulation of air through the fermenting house, fermenting on the floor is preferable to fermenting on racks, as in the latter case there is always a difference of several degrees of temperature on the different racks.

(5) The lighting of a fermenting room should be such that so direct sunlight or even direct glare reaches the tea. If this is avoided the ultimate result seems to be the same whatever the colour of the lighting; a blue light, however, appears to make the process somewhat more slow.

(6) The temperature of the air in contact with the fermenting leaf should be between 78° and 82° F.* to obtain the best results in the finished tea. If the temperature is above this point it can usually during most of the season be reduced several degrees by wet cloths hung outside and inside the fermenting house. At the end of the season it may be wise to raise the temperature to the figure above given. The coolest houses I know are those constructed at the base of high leaf houses, but any method of attaining the object is satisfactory.

(7) The atmosphere should be saturated with moisture, as any drying of the leaf which occurs during fermentation damages the resulting tea, causing the oxidation of the tannin, &c., to go too far.

* See my pamphlet "The Fermentation of Tea, Part II.," Calcutta, 1907.

(8) The fermenting room should be well aerated, because only $4\frac{1}{2}$ pounds of fermenting leaf are required to exhaust the oxygen from one cubic foot of air. It is probable that the ultimate arrangement for fermenting will provide for air being blown into the room through cloths kept constantly wet.

(9) The leaf should not be spread more than $1\frac{1}{2}$ inches thick, as above this the temperature is apt to rise in the inside of the fermenting layer. If the atmosphere is saturated, the thickness below this point does not apparently make any difference.

So far the conditions set out apply equally to tea of every kind. But if flavour is to be the prime object in manufacturing the tea, under the conditions usually found, and at the temperature already indicated, the time allowed (including the rolling) should not exceed three hours; if on the other hand, "liquor" is of paramount importance, then the fermentation should not take less than four hours. The loss of flavour which occurs when the leaf is fermented longer than three hours is probably due to the presence of microbes. Hence the more they can be eliminated the less danger there will be in giving a longer fermentation. It will be probably advisable in the plains to work primarily for liquor, that is to say to obtain by hard, but cool, rolling a leaf whose fermentation will last (including the rolling) from 4 to $4\frac{1}{2}$ hours at 75° F. to 84° F., and retain the maximum flavour possible by ensuring the most completely aseptic conditions by cleanliness in every detail.

FIRING.

We now pass to firing, and it certainly seems probable that a great deal of otherwise good tea is spoilt at this stage. In this connection I have clearly shown that—

(1) If the leaf takes a long time to dry there is always a loss both in the "liquor" and in the flavour. Anything resembling stewing means a decrease in the amount of soluble matter in the finished tea.

(2) If the temperature is too high in the leaf itself there is always a loss of flavour, and a loss of caffeine. The latter loss only seems to take place when the temperature is exceptionally high, but the flavour is rapidly reduced if the temperature goes over 200° F. Even when the temperature is below this point, and long continued, there is a very considerable loss of flavour.

It is perhaps difficult to reconcile these two conditions, for as usually understood in the past, the only way recognised as ensuring rapid firing was the raising of temperature. I feel that there is another method well worth considering at the present moment. That is the spreading of the leaf thinner than has been the custom and using more machines. An automatic machine on which the leaf is spread thinly will dry leaf equally if the inlet temperature is 200° F. to 220° F. as another on which the spreading is thicker which is run at 250° F. to 260° F., and the result would be considerably preferable. But owing to the fact that in all of the automatic machines at present on the market, the leaf is more or less stewed in the early part of the operation, the ideal conditions of firing do not at present seem altogether attainable. The best that can be done now seems to be to have ample firing machinery, spread the leaf very thin, run it through the machine very rapidly, bringing it out "12 annas fired," the inlet temperature not being above 220° F., and finishing off again as rapidly as possible on another machine at not higher than 180° F.

But the possibility of loss of quality is not over when the tea is fired. It has to be sorted, final fired and packed. The first of these operations does not come within my sphere, but much tea would appear to be damaged by inefficient final firing and too slow packing. From all the evidence at present in hand, the final-firing should be thorough, but at as low a temperature as possible or else flavour is liable to be lost. This leaves about two to three per cent. of moisture in the tea, but this amount is apt to increase rapidly if the tea is allowed to lie about. In fifteen hours in a tea factory in Assam, I have seen the moisture rise in a finished tea to nearly ten per cent. and with much less than this amount the tea would be liable to "go off" before reaching its destination. I feel confident that much of what is heard about tea "going off" in transit to England or elsewhere is due to it being packed, unknowingly, with say five or six per cent. (or possibly even with less) of moisture in it.

CONCLUSION.

We have now followed through all the factors which appear to influence the quality of tea. We have not found any one factor paramount, but have seen good reason to believe that good tea is the result of an enormous number of detailed causes, some under the control of a planter, some beyond his power and even beyond his knowledge. But once this is realised, and it is becoming increasingly realised in

the Indian tea districts, it will become obvious that the whole of tea planting merits more detailed study than has been given to it in the past. Our is a unique industry, one is which we are treading untrodden ground, and the study of every detail of the growth of the plant will well repay any attention given to it. Our knowledge is as yet imperfect beyond measure, but the methods which have led us so far will lead us further, and I do not think we ought to rest content until we have reached a quality of tea in any place which we are satisfied is incapable of improvement.

17-3-38

